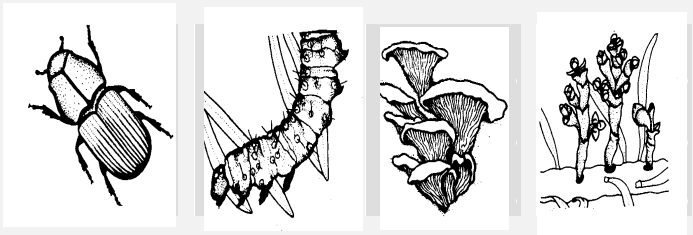
Forest Health Protection



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LIMBER PINE MORTALITY ON THE LEWIS AND CLARK NATIONAL FOREST, MONTANA

Jane Taylor[1], Nancy Sturdevant[2]

INTRODUCTION

Limber pine (*Pinus flexilis* James) populations at many locations in Montana have been showing symptoms of declining health over the past 5 to 6 years. The most significant damage appears to occur at locations on the Lewis and Clark National Forest (NF) in the north-central part of the state. Large numbers of trees have very thin crowns and poor terminal growth, and severe mortality is occurring in some areas. Several limber pine stands were examined in the summer of 1995, and no single, definitive cause of the decline was identified. In many of the locations, there was evidence of light defoliation caused by limber pine needle cast (*Lophodermella arcuata* (Darker) 1Darker). However, *L. arcuata* causes defoliation of only 1-year-old needles (Shaw and Leiphart 1960), and on the majority of the observed trees, 1-year-old needles were present, but needles 2 years old and older were absent. White pine blister rust (*Cronartium ribicola* Fisch.) does occur on the Lewis and Clark, and is known to cause high levels of mortality in some areas. However, the 1995 observations revealed a low rust incidence in the limber pine populations of concern, and no mortality could be attributed to the rust. Examinations for root disease pathogens were negative. The 1995 exams also revealed evidence of minor damage from an unidentified shoot-feeding insect and various secondary twig beetles. Scattered individual trees were found that had been killed by the mountain pine beetle (*Dendroctonus ponderosae* Hopkins). None of the pathogens or insects identified in 1995 were found to a great enough degree to be considered much of a factor in the overall tree decline problem, and the decline of the limber pine was attributed to a combination of factors including defoliation from needle cast, severe climatic events, plus the inherent harshness of the sites where limber pine grows.

In the summer of 1996, transects were established on the Lewis and Clark NF to record levels of damaging agents in an attempt to find a cause of the decline, and to monitor and document the current and future tree mortality. In 1998, a needle blight fungus, *Dothistroma septospora* (Dorog.) Morelet, was discovered causing severe defoliation and mortality of limber pine at various locations in Montana (Taylor and Schwandt 1998), including the areas of concern on the Lewis and Clark NF. The objectives of this paper are to present transect data from 1996-1998 on insect and disease activity and tree mortality on the Lewis and Clark National Forest, and to discuss the involvement of *D.*

[1]*Jane E. Taylor, USDA Forest Service, Forest Health Protection, Missoula Field Office, Missoula, MT 59807*

[2]*Nancy Sturdevant, USDA Forest Service, Forest Health Protection, Missoula Field Office, Missoula, MT 59807*

United States Department of Agriculture | Forest Service | Northern Region | 200 East Broadway P. O. Box 7669 Missoula, MT 59807

septospora in the limber pine mortality on the Lewis and Clark NF.

METHODS

Between June and August of 1996, four transects were established to monitor the limber pine decline on the Lewis and Clark NF (Figure 1). The transects were located in stands that showed moderate to severe tree damage and mortality. The transects were also chosen to represent variations in geography, elevation, aspect, habitat type and species composition. The four transects were established in the Lick Creek, Ettien Ridge, Dry Wolf Creek and Yogo Creek areas

Transects were established by following the slope through the approximate center of a stand or stringer of limber pine. Basic site information was recorded: slope, aspect and habitat type (Pfister et al. 1983). Between 48 and 75 limber pine trees in each stand were tagged and the following data were recorded: tree class, species, diameter at breast height (dbh), height, crown ratio, crown class, and insect and disease incidence and severity. Age was determined by taking increment cores from two limber pine trees in each 2-inch diameter class in each transect. All tree and site information was taken according to USDA Forest Service, Northern Region stand exam guidelines (USDA Forest Service 1991). Starting in 1998, trees were also rated for damage by *D. septospora*. If the tree showed evidence of *D. septospora* infection, it was estimated whether greater or less than 50% of the crown was infected.

RESULTS AND DISCUSSION

Site and tree characteristics

The sites ranged in elevation from approximately 6400 - 7330 feet (Table 1). The Yogo Town and Dry Wolf sites were almost pure limber pine and were classified as a limber pine/bluebunch wheatgrass (*Agropyron spicatum* (Pursh) Scribn. & Smith) habitat type. The Ettien Ridge transect was largely limber pine with a minor Douglas-fir (*Pseudotsugae menziesii* (Mirb.) Franco) component, and it was classified as a limber pine/Idaho fescue (*Festuca idahoensis* Elmer) habitat type. The Lick Creek transect was a mixed composition of Douglas-fir and limber pine, and it was classified as a Douglas-fir habitat type. Dry Wolf, Yogo Town, and Lick Creek transects were all positioned at lower to mid-slope. Dry Wolf and Yogo Town had southern exposures, and Lick Creek had a western exposure. The Ettien Ridge transect was positioned along a ridge top with a slight northwestern exposure.

Tree characteristics were summarized for data taken in 1996 (Table 1). The number of limber pine per transect ranged from 48 to 75. Average tree height on the transects at time of establishment ranged from 21.1 - 24.1 feet., and average dbh ranged from 6.4 - 7.3 inches. Thirty-nine percent of all trees were classified as dominant or codominant, 36% were intermediate, 13% were open-grown, and 12% were suppressed.

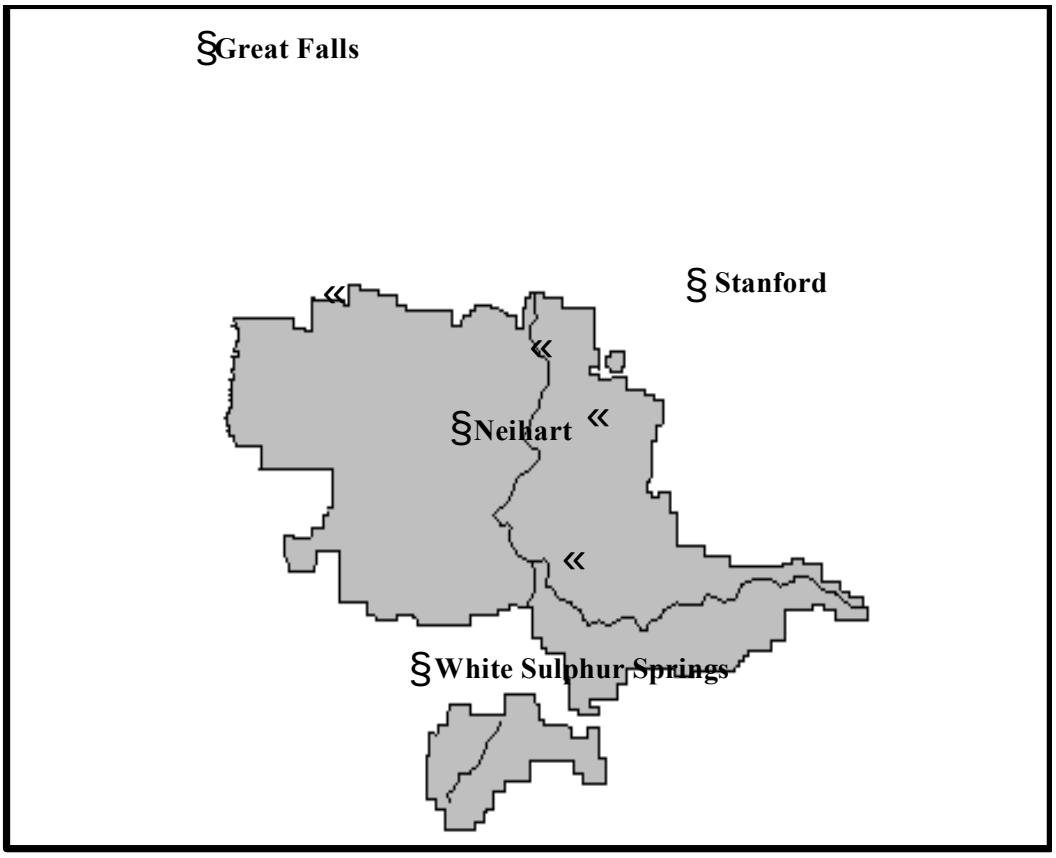

Figure 1. Location of limber pine monitoring transects ( ) on the Lewis and Clark National Forest, Montana.

Table 1. Transect characteristics and average characteristics of trees on the four transects (1996 data).

Transect	Elevation (ft.)	Slope (%)	Aspect	# Trees	Ave. tree age (sd*)	Ave. Tree Height (ft.) (sd)	Ave. tree dbh (in.) (sd)
Lick Creek	6500	20	W	48	56 (24)	24.0 (9.3)	7.3 (2.9)
Ettien Ridge	7330	5	NW	60	72 (18)	21.5 (5.3)	6.4 (3.0)
Dry Wolf	6400	30	S	65	71 (17)	21.1 (4.5)	6.9 (2.4)
Yogo Town	6400	30	S	75	96 (24)	24.1 (6.1)	7.2 (2.5)
Total				248	74.62 (24)	22.7 (6.4)	6.9 (2.7)

* sd = standard deviation

Insect and disease activity

Blister rust and Dothistroma needle blight were the only two disease agents found affecting trees on the transects from 1996-1998. A minor amount of sawfly (*Neodiprion sp.*) damage was noted each year, but no major insect activity was recorded. Because *D. septospora* was not identified until 1998, and because of inconsistencies in blister rust data collection, only the 1998 data on blister rust and needle blight severity and incidence were analyzed.

Dothistroma infection was quite prevalent in 1998. Data was recorded in August, and although many of the infected 2-year-old needles had been shed, enough needles were present to see symptoms and fruiting bodies of *D. septospora*. Symptom development was also evident on 1-year-old needles. Needle samples were collected on each transect, and the presence of *D. septospora* was verified through microscopic examination. Eighty-seven percent of all trees were infected with *D. septospora* (Table 2). Needle blight incidence on the transects ranged from 57% at Ettien Ridge to 100% at Dry Wolf and Yogo Town. Not only was the incidence of disease high, but the severity was high as well. Seventy-six percent of all infected trees had greater than 50% of their crowns affected by needle blight. On a transect basis, the percentage of infected trees with greater than 50% of their crowns affected ranged from 20% at Ettien Ridge to 100% at Dry Wolf. It was apparent that *D. septospora* had been active in these infected trees for least 2-3 years previously, as evidenced by absence of needles older than 1 year.

Forty-one percent of all trees were infected with *C. ribicola* (Table 3). The percent of trees infected with *C. ribicola* on each transect ranged from 36% at Ettien Ridge to 57% at Lick Creek. Although the rust incidence was fairly high, the severity of rust infection on the transects was quite low. Twenty-seven percent of all live trees (64% of infected trees) were rated as having branch cankers with no bole infections. Only 7% of all live trees (18% of infected trees) had some degree of topkill from rust. Although trees were not rated for amount of crown loss due to rust-caused branch mortality, personal observation was that the current level of rust-caused dieback overall was low.

Mortality

Cumulative tree mortality on the four transects in 1998 ranged from 12% at Ettien Ridge to 45% at Dry Wolf with an overall average of 24% (Table 4). The mortality rate was highest between 1996 - 1997. Eighty-five percent of the total mortality was determined to be associated with defoliation from *D. septospora*. The conclusion that *D. septospora* was associated with tree mortality was based on the high levels of infection recorded in 1998 combined with personal observations of damage and symptoms between 1995-1997 indicating that *D. septospora* was active in the study areas prior to its identification in 1998. At Dry Wolf and Yogo town, 100% of the mortality was associated with needle blight, whereas at Ettien Ridge, no mortality was associated with needle blight. Mortality associated with needle blight defoliation was highest on the transects on south-facing slopes. Perhaps trees on these south-facing sites are subjected to higher stresses such as hot temperatures or droughty soil conditions that make them less able to withstand the effects of severe defoliation.

Taylor and Schwandt (1998) provided a detailed description of the recognition and biology of *D. septospora* in limber pine. In general, mortality from *D. septospora* defoliation is uncommon in natural stands (Peterson 1981). The severe damage occurring on the Lewis and Clark NF may be due to the inherent harshness of the limber pine sites. Limber pine is found on dry, rocky sites that are typified by extreme winter weather and droughty summer conditions (Steele 1990). Because these sites are so marginal for tree growth, severe defoliation from *D. septospora* for

several successive years may be enough additional stress to cause substantial tree mortality.

Table 2. Summary of *D. septospora* infection data on the four transects.*

	trees infected with *D. septospora*		infected trees with <50% crown affected		infected trees with >50% crown affected	
Transect	#	% of total live tress	#	% of total infected	#	% of total infected
Lick Creek	36	97	10	28	26	72
Ettien Ridge	30	57	24	80	6	20
Dry Wolf	36	100	0	0	36	100
Yogo Town	63	100	5	8	58	92
Total	165	87	39	24	126	76

* 1998 data

Table 3. Summary of *C. ribicola* infection data on the four transects.*

	Trees infected with *C. ribicola*		# of infected trees by rust severity class** (% of live trees)			
	#	% of live trees	1	2	3	4
Lick Creek	21	57	6 (16)	3 (8)	6 (16)	6 (16)
Ettien Ridge	19	36	7 (13)	3 (6)	4 (8)	5 (9)
Dry Wolf	14	39	9 (25)	2 (6)	2 (6)	1 (3)
Yogo Town	24	38	13 (21)	7 (11)	2 (3)	2 (3)
Total	78	41	35 (19)	15 (8)	14 (7)	13 (7)

* 1998 data

**rust severity class:

1 - branch infections located > 2 feet from bole
2 - branch infections located 6 inches - 2 feet from bole
3 - bole infection or branch infection within 6 inches of bole
4 - topkill from rust

Table 4. Summary of tree mortality on the four transects.

Transect	Cumulative tree mortality by year (% of total trees)			% mortality attributed to *D. septospora*	% mortality attributed to *C. ribicola*
	1996	1997	1998		
Lick Creek	7 (15)	10 (21)	11 (23)	73*	18*
Ettien Ridge	4 (7)	7 (12)	7 (12)	0	71*
Dry Wolf	13 (20)	27 (42)	29 (45)	100	0
Yogo Town	3 (4)	11 (15)	12 (16)	100	0
Total	27 (11)	55 (22)	59 (24)	85*	12*

* balance of mortality was attributed to suppression

Only seven trees on all four transects were found to have been killed by *C. ribicola*; this accounted for 12% of the total mortality on all four transects (Table 4). Mortality from blister rust was highest on the Ettien Ridge transect. At Dry Wolf and Yogo Town, no mortality was attributed to blister rust.

Future mortality trends

Infection by *D. septospora* is quite cyclical in nature, and is closely associated with summer moisture events (Funk 1985). Therefore, it is difficult to speculate what the needle blight situation will be in the future. However, given the severe defoliation that has occurred during the past 3 years on the Lick Creek, Dry Wolf, and Yogo Town transects, it is likely that additional mortality will occur in the next few years as a result of *D. septospora* defoliation. The level of mortality will depend on many factors, including the needle blight disease level and the number and severity of stressful weather events. Although mortality from blister rust on the study transects is currently low, the disease is active in these areas. Over time, mortality from blister rust will probably increase.

The presence of *D. septospora* as a serious disease agent in limber pine, a species already facing the threat of blister rust, may have serious implications. During severe needle blight outbreaks, a substantial number of trees may be killed, and the survival of new seedlings may be severely limited by rust and needle blight.

Future monitoring

The transects on the Lewis and Clark NF will be monitored annually for mortality and insect and disease activity, with an emphasis on needle blight defoliation and blister rust damage. Additional transects have been established at various locations in Montana to further evaluate the effects of *D. septospora* defoliation on the decline of limber pine (Taylor and Schwandt 1998).

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